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August 6, 2001

EX PARTE OR LATE FILED

Ms. Magalie Salas, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Reference: FCC ET Docket 98-153
Revision of Part 15 Rules of the Commission's Rules Regarding
Ultra-Wideband Transmission Systems

Subject: Request to Exempt Ground Penetrating Radar from Rule Changes

Dear Ms. Salas:

INFRASENSE, for the past 12 years, has developed and utilized Ground Penetrating Radar (GPR) for evaluating the conditions of pavements and bridge decks. Our methodology and equipment is an adaptation of GPR technology that has been in regular use over the past 25 years.

The data that we develop with this technology provides valuable information to highway agencies for allocating and prioritizing maintenance and rehabilitation funds, and for implementing maintenance and rehabilitation programs. With this technology, highway and bridge deck inspections are carried out at normal driving speed, eliminating hazardous lane closures and dangerous work-zone exposure of agency personnel. Our industry has provided these services to every state highway agency, covering thousands of bridges and tens of thousands of lane miles of pavement. With the shortage of state highway agency personnel and an ever-demanding aging highway infrastructure, our GPR services provide an essential element in the national infrastructure program.

The GPR technology that we use employs a short (1 nanosecond) pulse radar system whose energy is composed of a range of frequencies, from 500 to 1500 MHz. It is thus characterized as an electromagnetic broadband/or ultrawide band (UWB) measurement device. These pulses are transmitted down into the roadway, and the echoes received back provide the data used for investigating the condition of the pavement or bridge deck. The radar antenna is pointed towards the ground, where most of the energy is directed. The power level of the signal produced by this equipment is very small – less than 1% of that produced by a common cellular phone.

With regard to FCC rulemaking, recommendations have been made which would severely restrict the frequency range of GPR devices, and possibly require specialized licensing. Such recommendations would put our industry out of business. These recommendations have been supported, in part, by flawed tests which do not reflect the manner in which the equipment is operated. In these tests, the GPR antenna is pointed into the air (rather than towards the ground) and its ambient radiation is measured.

GPR surveys are very small in scale, and take place over short periods of time. The suggestion that the signals produced by our work will interfere with communications and wireless technology is unreasonable and unfounded. While our equipment is unlikely to interfere with communications and wireless technologies, the remote possibility of such interference could be easily corrected within the resources of the companies in these areas. The bigger impact will be on the operators of GPR equipment, since this equipment will increasingly be subjected to the more powerful signals produced by an expansion of wireless systems operating in our frequency range.

We are an industry composed of small companies without the political or legal clout of the multi-billion dollar broadcast, communications, GPS and wireless industries. However, our smallness does not justify implementation of unreasonable and arbitrary restrictions only to serve the convenience of big industry.

We respectfully propose, given the small scale of our activity, its 25 year history providing valuable information to government and private agencies, and the lack of substantive data suggesting that there is, or will be a problem, that Ground Penetrating Radar equipment and its survey activity be exempt from any rules promulgated to restrict or control ultrawide band transmission systems, and exempt from any associated licensing requirements.

For your reference I have attached a Federal Highway Administration publication encouraging state highway agencies to utilize GPR. I have also attached newsletters produced by my firm outlining the numerous beneficial applications of Ground Penetrating Radar.

Respectfully submitted,

Kenneth R. Maser, PhD
President
INFRASENSE, Inc.

enclosures:
FHWA Filer
Infrasense Newsletters

cc:
Norman Mineta, Secretary of Transportation
Senator Edward Kennedy
Senator John Kerry
Congressman Edward Markey
Mr. Vincent Schimmoller, Deputy Executive Director, FHWA

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AUG 15 2001

FCC MAIL ROOM

August 6, 2001

Senator Edward Kennedy
315 Russell Senate Office Building
Washington, D.C. 20510

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The FCC is currently considering rulemaking changes that could severely restrict or possibly eliminate the entire GPR industry. The changes are being promoted by the multibillion dollar communications industry to promote its future development and ownership of the airwaves. In the process, the GPR industry, which is over 25 years old and has provided valuable services to a broad range of government agencies, is being treated as a possible annoyance, without any serious regard as to whether or not GPR really constitutes a problem.

A copy of Infrasense's recent letter to the FCC explaining our desire to be exempt from such rules and restrictions is attached. Also attached are materials forwarded to the FCC showing the applications of GPR.

I would greatly appreciate your support in this matter.

Respectfully yours,

Kenneth R. Maser, PhD
President
INFRASENSE, Inc.

attachments
- Letter to FCC
- FHWA Filer
- Literature

August 6, 2001

RECEI'   D

AUG 1 5 2001

FCC MAIL   OM

Congressman Edward Markey
2108 Rayburn Office Building
Washington, D.C. 20515

Reference: FCC ET Docket 98-153
Revision of Part 15 Rules of the Commission's Rules Regarding
Ultra-Wideband Transmission Systems

Subject: Request to Exempt Ground Penetrating Radar from Rule Changes

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August 6, 2001

Mr. Vincent Schimmoller
Deputy Executive Director
Federal Highway Administration
400 7th Street SW
Washington, D.C. 20590

Reference: FCC ET Docket 98-153
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Subject: Request to Exempt Ground Penetrating Radar from Rule Changes

Dear Mr. Schimmoller:

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Respectfully yours,

Kenneth R. Maser, PhD
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INFRASENSE, Inc.

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RECEIVED

AUG 15 2001

FCC MAIL ROOM

August 6, 2001

Senator John Kerry
United States Senate
Russell Senate Office Building
Washington, D.C. 20510

Reference: FCC ET Docket 98-153
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Dear Senator Kerry:

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attachments
Letter to FCC
FHWA Filer
Literature

A newsletter of recent developments in applications of sensors for infrastructure evaluation

INFRASENSE, Inc.

Fall 1997

INFRASENSE, Inc. 14 Kensington Rd. Arlington, MA 02174 781/648-0440 (phone) 781/648-1778 (fax) www.infrasense.com

Boston's 18 Mile Aqueduct Evaluated

Project Features Innovative Use of NDT Methods

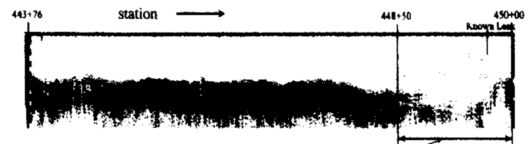
INFRASENSE recently conducted non-destructive evaluations for the Massachusetts Water Resources Authority (MWRA) for a major link in Boston's water supply — the 18 mile long Hultman Aqueduct. The project team led by Simpson, Gumpertz, and Heger (SGH), was the recipient of the American Consulting Engineers Council of New England (ACEC) Engineering Excellence, Grand Conceptor Award. The novel use of non-destructive evaluation was identified as a key factor in receiving this award. Through a combination of advanced technologies, the information obtained from the NDE surveys helped to identify areas in need of repair, and has increased the overall reliability of the aqueduct.

Infrared Survey

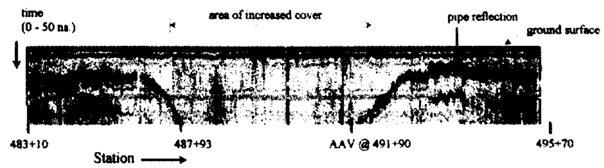
To find possible leak conditions, a helicopter-based aerial infrared survey was conducted on the entire length of the aqueduct. Both audio and video equipment were used in parallel with the infrared equipment to allow for simultaneous recording of observed conditions. The results of this infrared survey confirmed areas of known leakage and revealed leak locations which were previously unknown.

Ground Penetrating Radar (GPR)

Both longitudinal and transverse ground penetrating radar surveys were conducted on over 20,000 feet of the aqueduct. Areas of focus were determined by hot spots found during the infrared survey. The longitudinal data was analyzed to show areas of high moisture content, local distortions in the pipe reflections, areas of high conductivity and areas of high soil cover. The transverse data was analyzed to determine the relative moisture content in the soil cover, and to identify anomalies that could be related to leakage and voids at the pipe-soil interface.

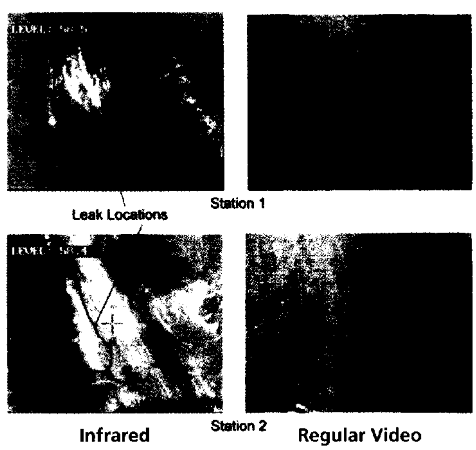


Data Showing Area of High Conductivity



Data Showing Area of Increased Cover

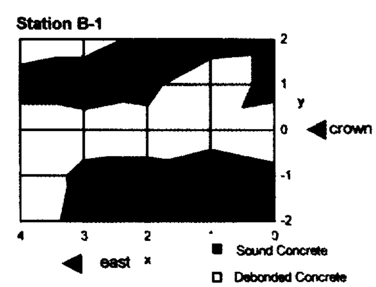
The results revealed areas of excessive overburden, confirmed areas of high corrosion potential, and identified a significant leakage channel.



Images showing potential leak locations

Ultrasonic Impact-Echo

Ultrasonic impact-echo testing was conducted to identify debonding and delaminated areas of the pipe wall. The results of the testing showed areas of debonding between the reinforced concrete wall and the steel liner.



Ultrasonic results showing debonded areas

Inside

INFRASENSE Celebrates its 10 Year Anniversary!!

INFRASENSE is celebrating 10 years of service to clients in the design and conduct of nondestructive evaluation programs including: infrared thermography, ground penetrating radar, ultrasonics and wireless data collection systems with applications to pavements, bridges, airfields, tunnels, aqueducts, storage tanks and railroad track. We would like to thank our clients for their valued business! At *INFRASENSE* we value success through teamwork, and we are committed to excellence in service. We look forward to serving all of your future needs!

– *Ken Maser, President*

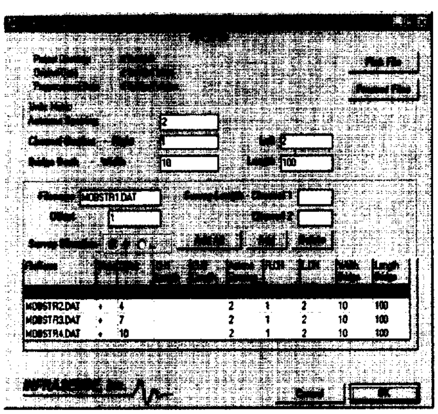
INFRASENSE Delivers Software for Pavement and Bridge Deck Analysis

Automated Analysis Now Available for Interpreting Ground Penetrating Radar (GPR) Data

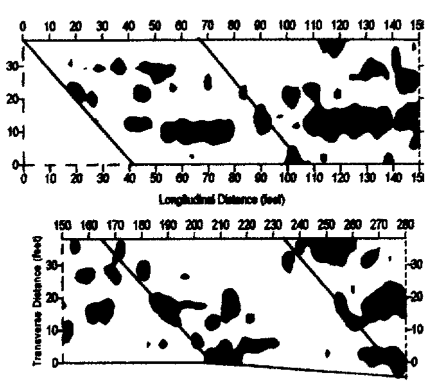
Software for automated analysis of pavement and bridge deck data is now available, and has been provided with training to the Florida Department of Transportation (FDOT) and the Korea Ministry of Construction (KMC). FDOT acquired PAVLAYER® for the evaluation of the 16,000 lane mile network to be covered in its pavement management system (PMS). KMC is acquiring DECAR® for evaluation of bridge decks and pavements throughout Korea.

Both programs are Windows based, and provide a graphical user interface to simplify data entry. More powerful data analysis routines are initiated by the user through the user interface, and the results are returned in formats that are easy to use and to plot for graphical presentation. Anthony Van Dyck, *Data Analysis Engineer,* of the Pavement Systems Evaluation Section of the State Materials Office (FDOT), feels that the PAVLAYER program has put them "On the cutting edge of technology."

DECAR Survey Analysis Screen



DECAR Sample Output Plot



Potential Areas of Delamination

PAVLAYER® Accuracy Evaluation Studies

Agency	Number of Sections AC[a]	PCC[a]	AC/PCC[a]	Number of Cores or Test Pits	Average Deviation (%)
TexDOT	12	1	--	90	5
Kansas DOT	11	--	3	73	7
Florida DOT	20	1	5	150	10
Washington DOT	1	1	1	5	8
Wyoming DOT	9	--	--	36	10
Mn/ROAD	15	10	--	74	5
USA-SHRP	10	--	--	68	7
US Air Force	6	6	1	13	6
US FHWA	--	2	2	10	5
Pforzheim (Germany)	26	--	--	35	8
Kent (UK)	5	--	--	76	5
TRL (UK)	3	1	--	115	6
Thüringen (Germany)	9	--	--	28	10
TOTALS	**127**	**22**	**12**	**817**	**7.5% (Mean)**

[a] AC = asphalt concrete; PCC = portland cement concrete; AC/PCC = AC over PCC

Anthony says that the system helps minimize their operator involvement in the most rudimentary levels, and assists in compiling accurate data for their pavement management system database.

> "We are on the cutting edge of this technology. This program . . . assists us in compiling accurate data for our pavement management system database"

Both PAVLAYER and DECAR were designed to make powerful ground penetrating radar (GPR) data processing techniques available to practitioners who are routinely involved with pavement and bridge deck evaluation. In the past, GPR data processing has been reserved only for the experts with a great deal of experience. With these programs, *INFRASENSE* has packaged this experience in a way that is accessible to a wider group of users.

PAVLAYER, for pavement layer structure analysis, was developed based on studies of over 150 pavement sections of different ages, conditions, and construction types. GPR data was collected on these sections, and the results were correlated with over 800 cores. The results of some of these studies are shown above. The FDOT PAVLAYER system was delivered as part of a project with the Texas Transportation Institute (TTI). This program, used in conjunction with the FDOT GPR system, enables data collection and analysis of up to 200 lane-miles per day. The PAVLAYER program organizes the analysis of files of collected GPR pavement field data, in a convenient way to facilitate the production of ASCII layer thickness reports and layer thickness plots. Two one-week training sessions were provided by *INFRASENSE* at the FDOT facility in Gainesville, FL.

Doria Kutrubes (top, center) of INFRASENSE in training session with (left to right) Earl Hall, Sandra Kang, and Stacy Scott of FDOT

DECAR is used to compute the deterioration of bridge decks and for determining the depth of reinforcement. The program was developed after several years of research and development which began at the Massachusetts Institute of

PAVLAYER® and DECAR® and their components are registered trademarks of *INFRASENSE, Inc.*

INFRASENSE Delivers Software continued on page 4

Pavement Evaluation Project Update

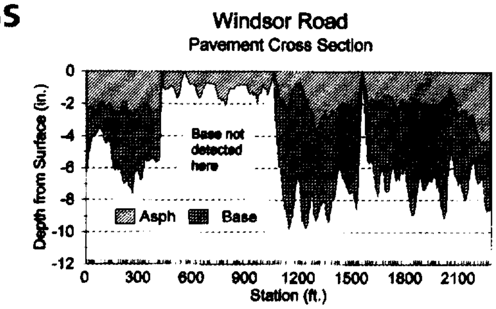
Local Pavement Management Program a Success

The trend in Europe towards the use of ground penetrating radar (GPR) for local community pavement management projects is catching on in the USA! As an example, *INFRASENSE* conducted pavement layer analysis on 43 streets, consisting of approximately 7.5 lane miles, in the Village of Thomaston, Nassau County NY. The overall objective of this project was to develop a pavement rehabilitation program for the Village. *Project Manager*, George Spitz from Shah/Trans Environ chose to work with GPR in this project because, "It was found to be the most advanced, valuable, non-intrusive technology that is used for determining foundation thickness and base layer material type." The pavement rehabilitation program required ERES Consultants Inc., Champaign IL, and *INFRASENSE* to provide information about the existing pavement structure. ERES Consultants conducted visual inspections of the pavement conditions as well as identification of the pavements structural capacity, through the use of a Falling Weight Deflectometer (FWD). To obtain accurate capacity calculations, input of the pavement layer thicknesses are also required, which is traditionally obtained through the use of coring. According to Curt Beckemeyer, P.E., *Division Manager of Evaluation and Design* for ERES Consultants, "GPR was a primary component in the decision making process for the project. Because

> "It (GPR) was found to be the most advanced, valuable, non-intrusive technology that is used for determining foundation thickness and base layer material type."

existing pavement records were not available and because coring is an exhaustive procedure, GPR was used as an expedient way to identify in-place pavement layer types and thicknesses."

The GPR survey vehicle was provided by Geophysical Survey Systems Inc., (GSSI) of Salem, New Hampshire and included radar equipment, survey operator and a 1GHz short pulse horn antenna, suspended from the back of the survey vehi-



cle as shown above. The GPR data from the radar survey was collected at normal driving speeds and the survey was conducted in one day. The data was then analyzed using *INFRASENSE'S* PAVLAYER® software (PAVement LAYer Evaluation using Radar) to determine the thickness of the surface and base layers and base layer properties.

The GPR survey results included detailed pavement thickness statistics on each road, and for the town as a whole. The results also highlighted some poor drainage areas where the base moisture content was very high. The information obtained for this pavement rehabilitation program provided the Village of Thomaston with the ability to schedule and prioritize their work, based on determined pavement conditions. For roads that were in better condition, periodic checks and maintenance on an as-needed basis were recommended.

Michigan DOT Applies GPR

On two occasions the Michigan DOT chose ground penetrating radar (GPR) as the selected method of technology to analyze its highways. District 3 near Cadillac Michigan, initially used GPR to review 66 miles of their highway pavement and as a result of this work, *INFRASENSE* conducted another survey for District 4.

Gary Kartunnen, *District 3 Design Engineer* of the Michigan DOT, was looking to obtain bituminous pavement thickness information for an upcoming resurfacing project. Kartunnen became aware of the use of GPR technology through Dave Smiley, *Supervising Engineer of the Pavement Technology Unit.* Smiley recommended GPR in lieu of traditional coring because he found, "The technology provides timely, readily accessible information, and was able to provide the degree of accuracy the DOT was looking for."

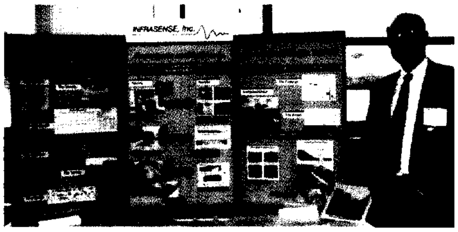
Shortly after the completion of the District 3 project, Bob Sweeney *Soils*

> "Traditional coring would not have been adequate because it provides spot information on selected areas, and they needed a running visual over the entire length of the road."

and Materials Engineer, District 4, became aware of GPR and its advantages. Sweeney was able to apply the value of GPR for a project that involved top course failure, and the need to know how much bituminous was left on a 13 mile stretch of Interstate 75. Bob Sweeney says GPR was appropriate for this project and that, "Traditional coring would not have been adequate because it provides spot information on selected areas, and they needed a running visual over the entire length of the road." Sweeney says, "GPR allowed them to isolate inadequate or potential weak spots," and with this information they were then able to increase the surface thickness where necessary.

As an additional benefit, Smiley notes, "Using GPR can free up funds for additional resources since there is no need to expend labor or impede the traffic conditions. . . we just need to make more people aware." When asked if Smiley would consider GPR for future projects, the answer was yes!

ASCE Infrastructure Condition Assessment Conference



Dr. Kenneth Maser at the ASCE Conference

INFRASENSE was a cosponsor of the 1997 ASCE Infrastructure Condition Assessment Conference held at the Boston Harborside Hyatt, August 25-27, 1997. The conference focused on technologies and systems for assessing and predicting the condition of roads, bridges, tunnels and water-supply systems.

Dr. Maser, President of *INFRASENSE*, presented papers on Wireless Global Bridge Evaluation and Monitoring System (WGBEMS), Condition Assessment Technology for Pavement Management in European Cities; and Leakage Evaluation of a Buried Aqueduct.

INFRASENSE Delivers Software continued from page 2

Technology, (MIT), and was continued and implemented by *INFRASENSE*. DECAR's uniqueness includes the ability to process data collected at highway speeds without lane closures and exposure of personnel to safety hazards or interference to traffic. The DECAR program results have been validated through research studies carried out by the transportation departments of Idaho, New Hampshire, Tennessee, and Wyoming.

The complex process of organizing and analyzing the GPR bridge deck data has been simplified in DECAR through the use of a single "Main Survey Analysis Screen" (see page 2). This screen directs the user through the various steps of the analysis, which ultimately lead to the output shown in the Figure. The analyzed data is automatically checked against the known bridge dimensions to insure that the correct results will be provided, and graphical output is then displayed. DECAR outputs include overlay thickness, depth of reinforcement and concrete dielectric properties, with an alternative analysis module based on SHRP C-101 also made available. DECAR provides output as both standard ASCII text files and as files that can be plotted using standard graphic programs.

SHORT NOTES

New Web site! *INFRASENSE* has recently constructed its own world wide web site. Look for PAVLAYER® and DECAR® software demonstration programs available for download in the near future.

New Area Code Please note that our new area code is 781 and will be required to complete all calls, effective December 1, 1997.

Mailing List Please help keep our mailing list up to date. Email your changes or suggestions to info@infrasense.com.

INFRASENSE, Inc.

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USA

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781/648-1778 (fax)

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A newsletter of recent developments in applications of sensors for infrastructure evaluation

INFRASENSE Update

Winter 1999

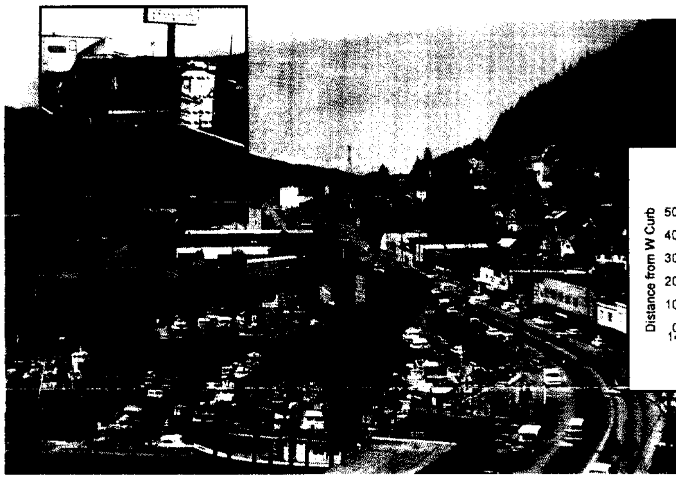
INFRASENSE, Inc. 14 Kensington Rd. Arlington, MA 02476-8016 USA
781/648-0440 (phone) 781/648-1778 (fax) E-mail: info@infrasense.com www.infrasense.com

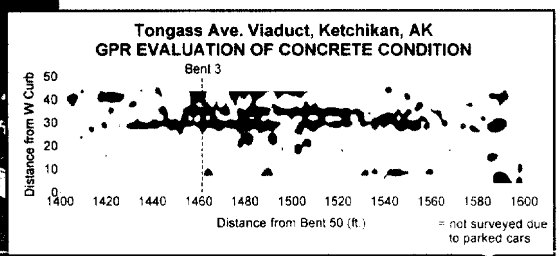
Deck Survey Conducted on Ketchikan Island, Alaska

As part of a subcontract with John S. Tinnea & Associates of Seattle, Washington, a GPR survey was conducted on the Tongass Avenue and Water Street Viaducts in Ketchikan, Alaska. The objective of the GPR portion of the survey was to assess the upper levels of the concrete decks under the asphalt overlay, and identify potential areas of damaged or delaminated concrete. Tinnea & Associates, specialists in the corrosion of steel in concrete, then conducted detailed evaluations of the two structures using the GPR maps for guidance. The findings of the survey were provided in report form, including photographs, data tables, and video. These assisted the Alaska DOT and Public Facilities Department (ADOT&PF) in determining repair and rehabilitation strategies.

Due to the travel distances involved, the GPR equipment was packed and transported by air as excess baggage and then mounted to a rented vehicle upon arrival in Ketchikan. The GPR data was collected from this vehicle while moving

GPR Ketchikan continued on page 4





Tongass Ave. Viaduct showing GPR equipment (left) with results above. (Equipment provided by Geophysical Survey Systems, Inc. (GSSI) North Salem NH)

Quality Control and Accurate As-Builts:

Finland Road Administration (FINNRA) and Mn/ROAD

GPR has been officially accepted for quality control of new asphalt construction and for as-built thickness evaluation of pavement research test facilities, as described below.

FINNRA Quality Control

After three years of extensive testing by the Finnish National Road Administration (FINNRA), GPR has been accepted as an official quality control method for new asphalt pavements.

Inside

The concept of using GPR for QC of asphalt air content was advanced in the early 1990's by Mr. Timo Saarenketo of Finland. The idea is based on using GPR for calculating asphalt dielectric values, and relating these values to air void content. Compaction of the hot mix asphalt leads to the removal of the low dielectric air from the higher dielectric aggregate and bitumen mix. The theory was tested at the Texas Transportation Institute in 1994-95, and at the University of Oulu in 1996-97. Between 1996-1998 a series of field tests were performed at various paving projects in Finland, and the laboratory results were confirmed.

According to Mr. Saarenketo, who is currently CEO of Roadscanners Oy, the GPR method has many advantages over conventional asphalt QC techniques: it is non-destructive, it provides continuous readings over the paved section, and it provides simultaneous measurements of asphalt thickness. The equipment can be mounted directly to a roller compactor (see figure) for real time quality monitoring of paving projects. The method is currently being used on projects in Finland through a

GPR antenna monitoring density and thickness behind roller compactor

FINNRA AND Mn/ROAD Quality Control continued on page 3

Civil Engineering NDE Course Offered by the University of Wisconsin

Some of the world's leading authorities in the field of non-destructive evaluation presented a continuing education course for civil engineers offered at the University of Wisconsin Milwaukee (UWM). The course was first held from September 30 - October 2, 1998, and as a result of the positive response of the course, UWM has scheduled it to take place again from February 24-26, 1999, at the Hotel Royal Plaza in Orlando Florida.

Dr. Maser demonstrating Ground Penetrating Radar equipment with Park Gilmore of Geophysical Survey Systems, Inc. (GSSI)

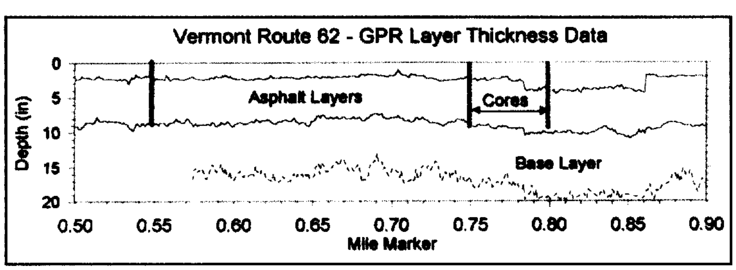
UWM introduced this in-depth course entitled, *Non-Destructive Evaluation of Civil Engineering Structures* for 1.8 CEU's as part of its extensive continuing education program. The course focused on topics regarding the latest effective NDE technologies currently in-use for the evaluation of civil structures, and on the practical applications of these technologies. *INFRASENSE*'s President, Dr. Ken Maser, provided a course presentation on Civil Engineering Applications of Ground Penetrating Radar (GPR) with emphasis on applications to highway, airfield and bridge deck evaluation. The various subtopics covered are: principles, advantages and limitations of GPR; applications and examples of previous work conducted; as well as an equipment demonstration.

For additional information regarding the participation of this course, please contact Program Director Steve Helminiak at the University of Wisconsin at (414) 227-3173 or via e-mail at sh@csd.uwm.edu; or Program Assistant Joyann Halvorson at (414) 227-3106. Registration information is also attainable directly through the University's Center for Continuing Engineering at (414) 227-3139, toll free 1-888-545-4700 or by visiting their web page at www.uwm.edu/dept/ccee.

Ground Penetrating Radar (GPR) Presentations Made to Several State DOTs: Pilot Surveys Included

INFRASENSE recently visited several area DOTs where presentations and equipment demonstrations on GPR were provided. The primary objective of the presentations was to distribute the most up-to-date information to state and federal engineers on the theory and applications of GPR for pavements and bridges. The presentations, which were made by *INFRASENSE*'s President, Dr. Ken Maser, focused on topics which included:

- Principles of GPR Applications
- Advantages and Limitations of GPR
- Applications to Pavements (Highway & Airfield)
- Applications to Bridges
- Demonstration of Data
- Highway GPR Equipment Demonstration



Sample results presented to the VAOT as part of a pilot study.

In conjunction with these visits, pilot surveys were carried out to address specific interests. Vermont focused on the application of GPR to network-level pavement layer thickness inventory data collection; while the NYS DOT was interested in using GPR for pavement thickness evaluation and detection of voids caused by infiltration into culverts. A survey was conducted for the Connecticut DOT to assess condition on an asphalt-overlaid bridge deck, while the Massachusetts Highway Department (MHD) tested the GPR system on a SHRP LTPP test site in Chicopee. The results of the thickness data was found to be within 97% of the core data collected by SHRP.

The New Hampshire DOT indicated it had already incorporated GPR for quality control of concrete cover on new bridge decks, and that it is also interested in GPR applications for condition assessment of older decks. A presentation was also made to the Kansas DOT whose interest has been on the evaluation of bare concrete bridge decks on heavily traveled urban interstate highways.

ConnDOT personnel reviewing GPR equipment (provided by Pulse Radar, Inc. Houston, TX)

If you would like to obtain additional information regarding the capabilities of GPR, or if you are interested in having *INFRASENSE* conduct a presentation or equipment demonstration for your agency, please contact us at 781/648-0440 or via e-mail at info@infrasense.com.

Tennessee Evaluates GPR for Bridge Decks

Study Shows Improvement in Repair Quantity Estimates

INFRASENSE conducted a pilot project for the Tennessee Department of Transportation (TN DOT) involving a survey of five asphalt-overlaid bridge decks that were scheduled for rehabilitation. The objective of the survey was to compare the accuracy of GPR with conventional methods. Wayne Seger of the Bridge Repair Section states that he, "found GPR useful because of its ability to collect data at highway speed, or low speed, without lane closures, exposure of personnel to safety hazards or interference to traffic".

Among the other benefits associated with using GPR are: the substantial field time and cost savings, 100% comprehensive linear coverage, the ability to incorporate this information into any highway agencies PMS system, its non-destructive nature, the many useful applications, and the automation of the results.

The five decks, located in three different counties, were surveyed in one day using GPR and the data was analyzed using *INFRASENSE*'s DECAR®. The results were evaluated for the TNDOT's use in preparing contract plans for bridge rehabilitation work. The GPR survey results were compared to the actual removal quantities and to the estimates that had been made by the TNDOT. When compared to prior estimates, the GPR results yielded quantity estimates closer to the actual removal quantities by 30% for partial depth repair and 35% for full depth repair.

A limitation noted by Mr. Seger was the turnaround time between the collection of the data and the transmission of the results. Since the time of the TNDOT project, advances have been made in the speed and efficiency of data processing. Each deck surveyed in the TNDOT project can now be processed in one day, and the results can be transmitted electronically to the agency for use the following day. Plans are underway for the state to employ the use of highway speed GPR for other bridge deck deterioration estimates in order to provide accurate cost projections, and scheduling for maintenance and rehabilitation.

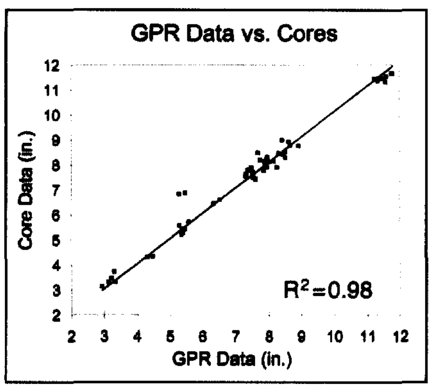
Mr. Wayne Seger evaluating repair quantities during rehabilitation of SR49 over the Harpeth River

FINNRA AND Mn/ROAD Quality Control continued from page 1

partnership between Roadscanners and FINNRA, Production Road Survey Division. For further information please contact Mr. Saarenketo at Timo.Saarenketo@roadscanners.com or Petri Roimela, FINNRA at Petri.Roimela@tiech.fi.

Mn/ROAD Tests As-Builts

The Minnesota Road Research Project (Mn/ROAD), wished to obtain accurate as-built thickness on all 40 of its research pavement sections. This information was important for characterizing pavement deterioration and modulus changes over time. The only core data available, however, was in the transition areas between the test sections, and coring within the research sections was not acceptable. To meet this need, *INFRASENSE* carried out a GPR thickness survey similar to that carried out at SHRP LTPP test sites and at the WesTrack facility in Nevada. *INFRASENSE*'s PAVLAYER® analysis software was used to process the data, and the results were provided in graphical as well as ASCII file formats. In order to test the capability of the GPR system, Mn/ROAD conducted a "blind test". The computed layer thickness results for the 74 transition area core locations were submitted to Mn/ROAD, without knowledge of the core thickness data. A correlation was then carried out between the core data and PAVLAYER® data for asphalt thickness, showing an average deviation between radar and core data 0.24 inches for asphalt. These results show that a high degree of accuracy can be expected for newly constructed pavements, and that GPR can be a useful tool for pavement thickness quality control.



Mn/ROAD Blind test results

Arizona Conducts Statewide GPR Bridge Deck Survey

The Arizona Department of Transportation has implemented a statewide bridge deck GPR survey as part of an overall bridge inspection and evaluation program. The lead consultant on the program, Burgess & Niple (B&N) of Columbus, OH, will be responsible for the complete inspection of 134 bridges. The deck component of this inspection will begin after *INFRASENSE* provides detailed maps of concrete condition and rebar depth for each of the decks. B&N will use these maps to plan more detailed tests, to locate test samples and to determine drill depths for chloride samples. The project will provide Arizona with 100% coverage data on deck condition and depth of rebar on over 1.5 million square feet of bridge deck, and the results will be available in 3 months at an affordable unit cost per bridge. GPR has been chosen for this project because it allows non-contact, non-destructive evaluations on as many as 12 bridges per day, without lane closures, interference to traffic or exposing personnel to safety hazards. Watch for more details in an upcoming issue of Better Roads Magazine and in the next *INFRASENSE* Update.

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GPR Ketchikan
continued from page 1

with traffic, and multiple passes were carried out using a series of round trips across each deck, spaced transversely at 3 foot intervals. The survey was over 2,900 feet in length, with a curb to curb width of 50 feet, and was conducted within 5 hours field time, without interference to traffic.

Meeting the schedule requirements of the project, preliminary GPR results for the Tongass Ave. Viaduct were provided within four days of completion of the data collection. The final output of the GPR survey was a set of maps indicating areas of likely damaged and delaminated concrete, and a computation of the total deck area that was affected. The maps were used by Tinnea & Associates to identify locations for conducting more detailed local evaluations, including coring and half-cell tests. Plans, specifications and estimates are currently being developed for ADOT&PF to use in the repair and rehabilitation of the two Viaducts.

SHORT NOTES

INFRASENSE will be represented at the following events — look for upcoming papers, presentations and lectures on the subject of non-destructive evaluation and Ground Penetrating Radar.

University of Wisconsin Milwaukee (UWM)
Non-Destructive Evaluation of Civil Engineering Structures Course
February 24-26, 1999
Orlando Florida
www.uwm.edu/dept/ccee

ACI Spring Convention 1999, ACI Report 228-2R-98: Non-Destructive Test Methods for Evaluation of Concrete in Structures
March 14-19, 1999
Chicago Illinois
www.aci-int.org

FAA 1999 Airport Technology Transfer Conference
April 11-15, 1999
Atlantic City New Jersey
www.airtech.tc.faa.gov

Structural Engineers World Congress Conference (SEWC)
April 19-22, 1999
New Orleans Louisiana
www.asce.org/conferences/structures99

TRB International Bridge Management Conference
April 26-28, 1999
Denver Colorado
www.nas.edu/trb/calendar

ASTM Third Symposium on Nondestructive Testing and Backcalculation of Moduli Conference
June 30-July 1, 1999
Seattle, Washington
www.astm.org

8th International Structural Faults & Repair, 1999 Conference
July 13-15, 1999
Commonwealth Institute, Kensington, London UK
www.ecspublications.com

GPR Equipment and Service Providers

Geophysical Survey Systems, Inc.
13 Klein Drive
North Salem, NH 03073
Phone: 603-893-1109
Fax: 603-889-3984
http://www.geophysical.com/
Equipment vendor

Infrasense, Inc.
14 Kensington Road
Arlington, MA 02476
Phone: 781-648-0440
Fax: 781-648-1778
http://www.infrasense.com/
Service provider

Penetradar Corporation
2509 Niagara Falls Blvd.
Niagara Falls, NY 14304
Phone: 716-731-4369
Fax: 716-731-5040
Service provider

Pulse Radar, Inc.
3535 Briar Park Drive
Houston, TX 77042
Phone: 713-977-0557
Fax: 713-977-2159
Email: roadar4@aol.com
Equipment vendor and service provider

Road Radar, LTD
14535-118 Avenue
Edmonton, Alberta
CANADA T5L 2M7
Phone: 403-453-5873
Fax: 403-454-5688
http://www.rrl.com/
Service provider

Sub-Surface Informational Surveys, Inc.
145 Shaker Road
East Otis, MA 01029
Phone: 413-525-4666
Fax: 413-525-2887
http://home1.gte.net/bacan/
Service provider

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Prepared by the Office of Asset Management. For more information, call 202-366-0392.

Publication Number: FHWA-HIF-00-015

Ground Penetrating Radar for Measuring Pavement Layer Thickness

U.S. Department of Transportation
Federal Highway Administration

Highway agencies and contractors now have a new tool for estimating the remaining service life of pavements and selecting the appropriate maintenance and rehabilitation activities—ground-penetrating radar (GPR). GPR systems collect pavement layer thickness data quickly, unobtrusively, and inexpensively. Using GPR, pavement management engineers can survey subsurface conditions at a small fraction of the cost of conventional core sampling and gather data for network-level pavement management.

What is ground - penetrating radar?

GPR is a pulse-echo method for measuring pavement layer thickness and other properties. It works like ultrasound, but uses radio waves rather than sound waves to penetrate the pavement.

Antennas mounted on a moving vehicle transmit short pulses of radio wave energy into the pavement (see figure 1). As this energy travels down through the pavement structure, echoes are created at boundaries of dissimilar materials (such as the asphalt-base interface). The arrival time and strength of these echoes can be used to calculate pavement layer thickness and other properties, such as moisture content.

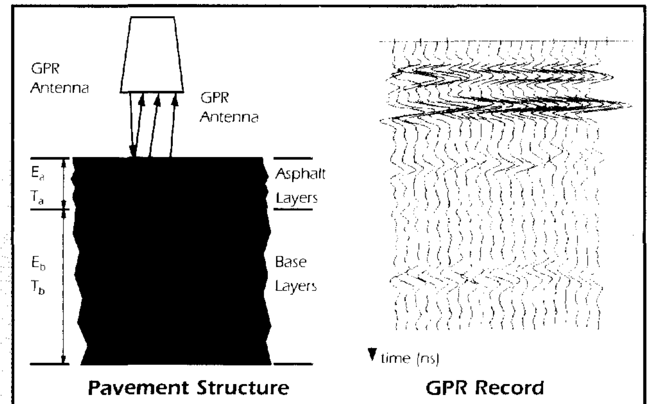


FIGURE 1:
Principles Used for Measuring Pavement Thickness

Why use GPR?

GPR systems yield accurate data in a form ready for management consideration. They survey pavements quickly, cost-effectively, and with minimal traffic disruption and safety risks. The Strategic Highway Research Program (SHRP), the Federal Highway Administration (FHWA), and several States and other agencies have carried out studies of GPR (see "Further Information" Section) that demonstrate the advantages of this automated surveying system.

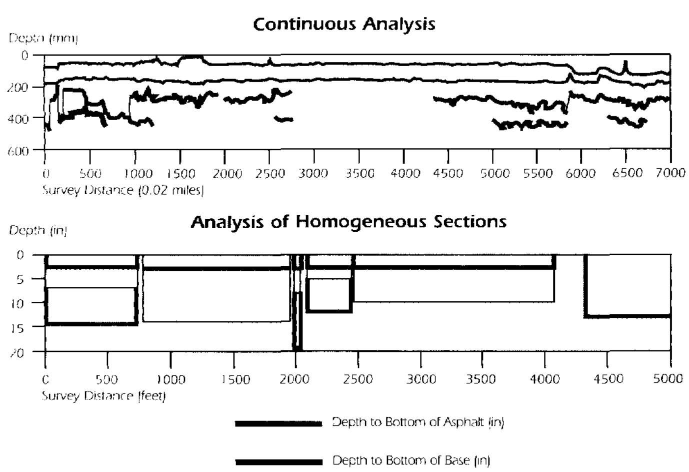
FIGURE 7:
Output of GPR Surveys

Continuous Analysis

Distance (miles)	Thickness Asphalt (mm)	Thickness Base (mm)
.001	171.338	266.816
.011	172.064	275.062
.021	172.004	261.257
.031	178.452	278.780
.041	169.455	287.135
.051	172.131	295.694
.057	172.730	310.635
.059	181.170	121.075
.069	172.251	110.218

Homogeneous Section Analysis

Station (ft.) Begin	Station (ft.) End	Mean Layer Thickness ASPH	Mean Layer Thickness Base
5	739	7.05	8.25
779	1953	13.96	0.00
1993	2038	8.12	11.50
2087	2448	5.08	7.07
2460	4066	9.74	0.00
4321	6408	12.92	0.00
6421	6489	15.05	0.00
6491	6567	19.68	0.00
6567	6697	15.39	0.00
6701	8773	11.06	0.00



The advanced GPR technology is not only available, but it has also been tried and tested. Denmark, Finland, and the United Kingdom are already using GPR in their pavement evaluation programs, as are several States, including Florida, Louisiana, Michigan, North Carolina, and Texas. Some States operate their own GPR equipment and perform their own analyses, and some contract the survey work. Other States, including Wyoming, Idaho, Minnesota, and Kansas, are evaluating GPR options.

Field tests and evaluative reviews conducted over the past decade have examined the accuracy and efficiency of GPR performance as a network pavement management tool for measuring pavement layer thickness. The studies have established the following benefits and limitations:

- **Lower Surveying Costs—** GPR provides 100 percent pavement coverage at a small fraction of the cost of taking conventional core samples.

- **Management Utility—** GPR thickness data can be imported directly into a pavement management system to provide accurate data for calculating the remaining life of pavement sections, selecting the appropriate maintenance and rehabilitation actions, and developing specific rehabilitation designs. Software converts the radar readings into ASCII file output or graphical representations. Survey data can be displayed in continuous form or for discrete homogeneous sections.

Ground-Penetrating Radar:
*Range of Accuracy for Pavement Layer Thickness Measurements**

Layer Type	Accuracy (vs. Cores)
New asphalt	3–5%
Existing asphalt	5–10%
Concrete	5–10%**
Granular base	8–15%**

*Maser, 1996

**Requires adequate contrast between layer materials

- **Limitations**— GPR may not always be able to detect the thickness of concrete pavement or the thickness of the base layer if there is insufficient contrast between the concrete and the base below. Agencies should be aware of the capabilities of GPR and stay within those boundaries, which produce reliable results.

Getting Started

Agencies can opt to purchase equipment and software or to contract for GPR survey services. Costs vary with the number of antennas and the vehicle and system options. Operation requires a minimum of two trained operators.

Purchase Option
(estimated costs)

- $150,000–$250,000
- Radar equipment
- Vehicle and support equipment
- Software
- Training

Contracted Services Option
(estimated costs)

- $18.50–$37.00/lane-km ($30–$60/lane-mile) at the network level
- Equipment, operator, and driver—$1,500/day
- Mobilization—$500/day
- Data analysis (16–40 km/day [10–25 miles/day])—$500/day

Specific costs can be obtained from the equipment vendors and survey service providers listed in this brochure. In addition, a Federal Communications Commission permit is needed each time radar is used by a State or radar vendor.

Further Information

Fernando, E. 1992. *Highway Speed Pavement Thickness Surveys Using Radar.* Final Report prepared for the Federal Highway Administration. Texas Transportation Institute.

- Pavement layer thickness

Fernando, E., and K.R. Maser. 1996. *Development of a Procedure for the Automated Collection of Flexible Pavement Layer Thicknesses and Materials: Phase IIB—Final Report.* Florida DOT State Project 99700-7550.

- Network pavement evaluation

Maser, K. 1994. *Ground Penetrating Radar Surveys to Characterize Pavement Layer Thickness Variations at GPS Sites.* Strategic Highway Research Program, SHRP–P-397.

- Pavement layer thickness for long-term pavement performance

Maser, K. R. 1996. Evaluation of Pavements and Bridge Decks at Highway Speed Using Ground Penetrating Radar. *Proceedings, ASCE Structures Congress XIV.* Chicago, IL. 15–18 Apr.

- ITD—Bridge decks and pavement thickness (1995)
- MnROADS—QA of pavement thickness (1995)
- TRL (UK)—Network pavement evaluation (1993)
- WTD—Bridge decks and pavement thickness (1994)

Mesher, D., C. Dawley, and B. Pulles. 1997. *Application of Ground Penetrating Radar Technology for Evaluating and Monitoring Asphalt Thickness Concrete Pavement Structures.* Edmonton, Alberta, Canada: EBA Engineering Consultants Ltd.

National Cooperative Highway Research Program Synthesis 255. 1998. *Ground Penetrating Radar for Evaluating Subsurface Conditions for Transportation Facilities.* Transportation Research Board, National Research Council. March.

Scullion, T., C. L. Lau, and Y. Chen. 1992. *Implementation of the Texas Ground Penetrating Radar System.* Research Report 1233-1. Texas Transportation Institute.

- Layer thickness accuracy

GPR can reveal other conditions that are not visible at the surface (like moisture content). When used on concrete, GPR reveals steel reinforcing bars, full-depth asphalt patches, and joint spacing, as shown in these GPR records.

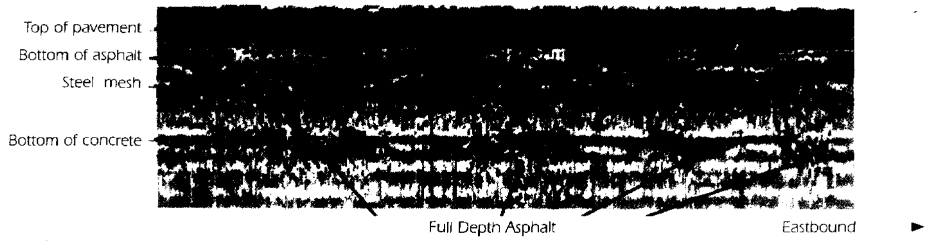


Figure 2:
GPR Record of Asphalt-Overlaid Concrete, Showing Evidence of Full-Depth Patching in Concrete

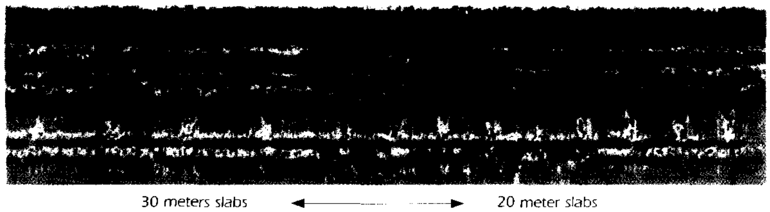


Figure 3:
GPR Record Showing Transition in Slab Length from 30 to 20 Meters

- **Greater Efficiency**— GPR systems are fast and efficient. Radar-equipped vehicles—like those shown here—typically cover as many as 322 km per day (200 miles per day), moving at normal highway speeds. Automated data collection reduces survey time dramatically and makes the process nearly invisible to the traveling public.

- **Increased Safety**— GPR minimizes the exposure of highway workers to dangerous situations. It requires no road crews, lane closures, congestion, traffic backups, or core patching. Workers are not exposed to high-speed traffic, weather, noise, or pollution, and the traveling public escapes the frustrations, delays, and attendant safety risks of lane closures.

- **Adequate Accuracy**— GPR pavement thickness data are accurate to within 3–15 percent of data obtained through conventional core samples (Maser, 1996), levels appropriate for network-level pavement management. Accuracy varies slightly with paving material, and research has established typical GPR accuracy levels for GPR surveys of four types of pavement layers:

Figure 4:
European GPR Van

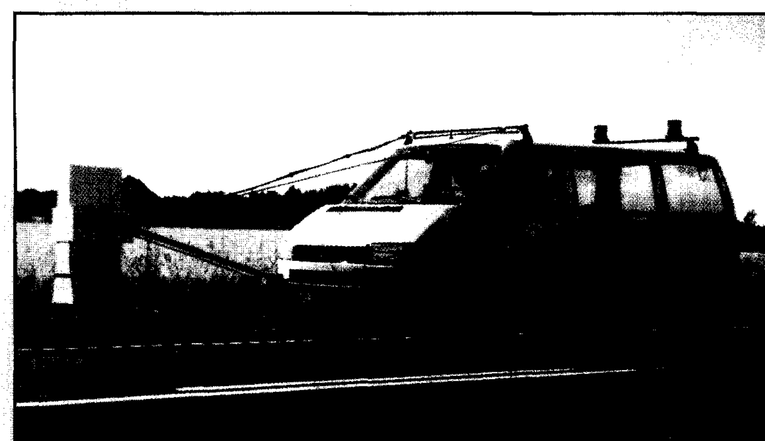


Figure 5:
FHWA Radar Unit

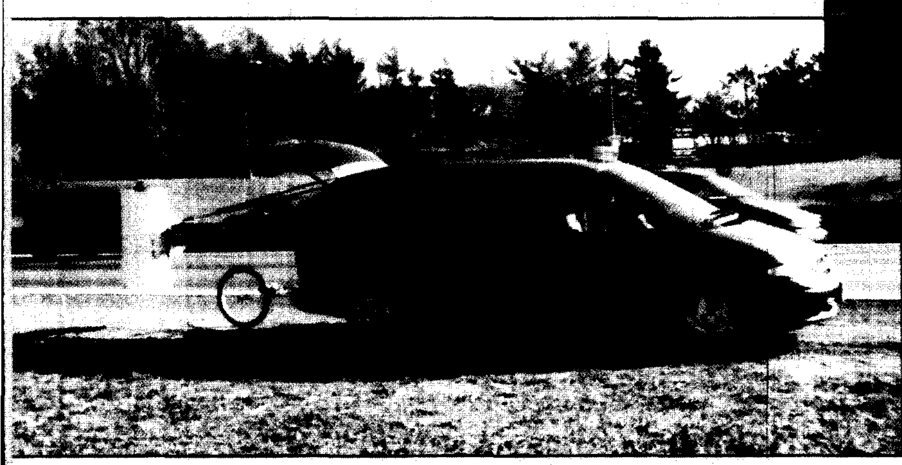


Figure 6:
Portable GPR Equipment Mounted on Rented Vehicle